

REMARKS

Status of the Claims:

Claims 1 – 24 are pending.

Claims 1 – 12 are rejected.

Claims 7 – 12 are objected to.

Claims 1 – 5, 7 and 9 – 12 are currently amended.

Claims 13 – 24 are cancelled.

Claim 25 is a new claim.

Amendments to the Claims:

No new matter has been introduced by way of the claim amendments.

Claim 1 is amended to recite that the substoichiometric amount of the functionalizing species is selected such that a preferential reaction of the functionalizing species occurs with metallic and semimetallic carbon nanotubes over semiconducting carbon nanotubes. Claim 1 is also amended to clarify that the plurality of suspended carbon nanotubes comprise metallic carbon nanotubes, semimetallic carbon nanotubes and semiconducting carbon nanotubes. Support for these amendments may be found in at least paragraphs [0011], [0024], [0026], [0030], [0036], [0038], [0046] and [0055]. All other amendments to claim 1 are for clarification purposes or to provide proper antecedent support within the claim.

Claim 2 is amended to recite that the substoichiometric amount of the diazonium species is selected such that a preferential reaction of the diazonium species occurs with metallic and semimetallic carbon nanotubes over semiconducting carbon nanotubes. Claim 2 is also amended to clarify that the plurality of suspended carbon nanotubes comprise metallic carbon nanotubes, semimetallic carbon nanotubes and semiconducting carbon nanotubes. Support for these amendments may be found in at least paragraphs [0011], [0024], [0026], [0030], [0036], [0038], [0046] and [0055]. All other amendments to claim 2 are for clarification purposes or to provide

proper antecedent support within the claim.

Claim 3 is amended to recite that the substoichiometric amount of the diazonium species is selected such that a preferential reaction of the diazonium species occurs with metallic and semimetallic carbon nanotubes over semiconducting carbon nanotubes. Claim 3 is also amended to clarify that the mixture of surfactant-suspended carbon nanotubes comprises metallic carbon nanotubes, semimetallic carbon nanotubes and semiconducting carbon nanotubes. Support for these amendments may be found in at least paragraphs [0011], [0024], [0026], [0030], [0036], [0038], [0046] and [0055]. All other amendments to claim 3 are for clarification purposes or to provide proper antecedent support within the claim.

Claims 4 and 5 are amended to correct a grammatical error.

Claims 7, 9, 11 and 12 are amended to eliminate improper multiple dependencies.

Claim 25 is a new claim. Support for new claim 25 may be found in at least claim 11 as originally filed.

All other amendments to the claims not described hereinabove have been made for stylistic purposes.

I. Response to Restriction Requirement Under 35 U.S.C. § 121 and 372

The Examiner has identified three groups of inventions in the application that are subject to restriction. Office Action page 2, item 1. These groups are as follows:

Group I: claims 1 – 12, drawn to a method of functionalizing carbon nanotubes,

Group II: claims 13 – 19, drawn to a method of separating carbon nanotubes, and

Group III: claims 20 – 23, drawn to a composition of functionalized carbon nanotubes.

Applicants respectfully call to the Examiner's attention that it appears that claim 24, which depends from claim 23, should also be included in Group III.

Applicants provided instructions to the Examiner by telephone interview conducted on September 16, 2008, at which time Applicants made a provisional election of Group I, claims 1 – 12. Office Action page 2, item 3. Applicants confirm the election of Group I, claims 1 – 12 with this response. Applicants' election is made without traverse.

Applicants have cancelled claims 13 – 24 drawn to the non-elected groups of inventions. Applicants reserve rights to file one or more divisional applications on the non-elected inventions at a later date.

II. Objections to the Drawings

The Examiner has objected to the drawings because the structure of the molecular name of the diazonium salt is unclear. Office Action page 5, item 6. Applicants presume that the Examiner is referring to the diazonium salt structure found in Figure 6. In response to the Examiner's objection, Applicants submit a complete listing of replacement drawing sheets filed under separate cover from this response. The replacement drawing sheets include a clear diazonium salt structure in Figure 6. No new matter has been introduced in the replacement drawing sheets. Applicants respectfully request that the Examiner's objection to the drawings be lifted in view of Applicants' submission of a complete list of replacement drawing sheets.

III. Claim Objections

Claims 7 – 11 and 12 are objected to for being in improper multiple dependent form. Office Action page 5, item 7. Applicants have amended claims 7, 9, 11 and 12 to eliminate the improper multiple dependencies.

IV. New Claims

Claim 25 is a new claim. Claim 25 has been added in order capture subject matter previously claimed in improper multiple dependent claim 11.

V. Claim Rejections Under 35 U.S.C. § 112

Claim 1 stands rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the Applicants regard as the invention. The Examiner asserts that the phrase "preferentially with" renders the claim indefinite because the claim includes elements not actually disclosed (those encompassed by the phrase "or the like"). Applicants respectfully traverse the Examiner's rejection of this claim.

Applicants respectfully call to the Examiner's attention that claim 1 does not contain the indefinite phrase "or the like" in its original form. Applicants respectfully assert that claim 1, as presently amended, complies with 35 U.S.C. § 112, second paragraph, requirements. As presently amended, claim 1 describes a preferential reaction of a functionalizing species that occurs with metallic and semimetallic carbon nanotubes over semiconducting carbon nanotubes. Applicants respectfully assert that a preferential reaction is clearly understandable based on at least paragraphs [0010], [0011] and [0026] of the instant specification. In view of the foregoing remarks and amendments, Applicants respectfully request that the Examiner's rejection of claim 1 under 35 U.S.C. § 112, second paragraph, be withdrawn.

VI. Claim Rejections Under 35 U.S.C. § 102

VI.1 Claims 1, 2, 4, 5, 8, 10 and 12 rejected under 35 U.S.C. § 102(b)

Claims 1, 2, 4, 5, 8, 10 and 12 stand rejected under 35 U.S.C. § 102(b) as unpatentable over Bahr, *et al.*, *J. Am. Chem. Soc.* 2001, **123**, pp. 6536 – 6542 (hereinafter, *Bahr*). Office Action page 7, item 8. Applicants respectfully traverse the rejection of these claims.

The Examiner asserts that *Bahr* teaches functionalization of carbon nanotubes with diazonium salts carried out via electrochemical reaction in solution. The Examiner asserts that *Bahr* teaches that small-diameter carbon nanotubes display enhanced reactivity over larger [sic]-diameter tubes. Further, the Examiner asserts that *Bahr* teaches that the carbon nanotubes have electronic properties based on the different tube diameters and chiral indices that give the reactivity. The Examiner asserts that *Bahr* teaches estimated stoichiometries for the functional species (diazonium salt) and the carbon atoms in the nanotubes. The Examiner further asserts that *Bahr* teaches that some tube diameters provide a greater degree of functionalization.

With regard to the dependent claims, the Examiner asserts that *Bahr* teaches single-wall carbon nanotubes, different types of aryl diazonium salts, preparation of diazonium compounds from aniline derivatives and nitrosonium tetrafluoroborate, and thermal removal of functionalized moieties.

Applicants' reading of *Bahr* follows. *Bahr* teaches a reaction of carbon nanotubes with a diazonium species under electrochemical conditions. Further, *Bahr* teaches that small-diameter

carbon nanotubes display preferential reactivity with diazonium species due to their curvature strain (for example, see *Bahr*, page 6537, first paragraph, lines 6 – 7). *Bahr* teaches conditions under which semiconducting carbon nanotubes are at least partially functionalized (for example, see *Bahr*, page 6537, paragraph 3 (characterization), lines 3 – 14 through page 6538, paragraph 1, lines 1 – 5 and Figures 3 and 4). The fine structural features displayed in the unfunctionalized, purified SWNT-p absorption spectrum shown in Figure 3 of *Bahr* are taught to be characteristic of semiconducting carbon nanotubes. The fine structural features disappear or are radically altered in the absorption spectra of SWNTs 1 – 9 (for example, see *Bahr*, page 6537, paragraph 3 (characterization), lines 9 – 14 through page 6538, paragraph 1, lines 1 – 3 and Figures 3 and 4). This spectral alteration is taught by *Bahr* to be consistent with covalent functionalization of semiconducting SWNTs (for example, see page 6538, paragraph 1, lines 3 – 5).

Applicants point out for the Examiner's reference that the quantities of the diazonium species used in the electrochemical reactions taught by *Bahr* are significantly greater than the substoichiometric amounts utilized by Applicants. For example, *Bahr* teaches that a piece of buckypaper (1 – 2 mg) is used as the working electrode of a three-electrode electrochemical cell, and diazonium salt solutions of 0.01 – 0.05 M in concentration are employed (see *Bahr*, page 6541, paragraph 10, lines 3 – 5 and page 6542, paragraph 1, lines 6 – 7). Taking the extreme limits of 2 mg of carbon nanotubes and a 0.05 M diazonium salt solution, these amounts translate to approximately 3.3 mL of diazonium salt solution required to achieve a 1:1 mole ratio diazonium salt to carbon nanotube carbon. This amount represents a reasonable volume for a three-electrode electrochemical cell. Even in the opposite limit of a 0.01 M diazonium salt solution, only approximately 16.7 mL of diazonium salt solution is required to achieve a 1:1 mole ratio of diazonium salt to carbon nanotube carbon. It will be understandable to one skilled in the art that the quantities taught by *Bahr* are stoichiometric quantities, since there is essentially an equivalent mole to mole relationship of the diazonium species relative to the carbon nanotube carbons. In contrast, Applicants claims describe substoichiometric quantities, which will be understandable to one skilled in the art as less than an essentially equivalent mole to mole relationship.

Applicants have amended claim 1 to recite a limitation that a substoichiometric amount

of a functionalizing species is selected such that a preferential reaction of the functionalizing species occurs with metallic and semimetallic carbon nanotubes over semiconducting carbon nanotubes. Applicants' claim 1 is distinguished from *Bahr* in that *Bahr* clearly does not teach a substoichiometric amount of a functionalizing species for producing a preferential reaction, since *Bahr* expressly teaches a reaction of semiconducting carbon nanotubes. Further, a preferential reaction of metallic and semimetallic carbon nanotubes over semiconducting nanotubes is not inherent from *Bahr* or established through routine experimentation. *Bahr's* purpose is to achieve highly functionalized carbon nanotubes. As would be evident to one skilled in the art, there is no motivation to use a deficiency (substoichiometric amount) of a functionalizing species to produce the highly functionalized carbon nanotubes taught by *Bahr*.

Applicants have amended claim 2 to recite a limitation that a substoichiometric amount of a diazonium species is selected such that a preferential reaction of the diazonium species occurs with metallic and semimetallic carbon nanotubes over semiconducting carbon nanotubes. Applicants' claim 2 is distinguished from *Bahr* in that *Bahr* clearly does not teach a substoichiometric amount of a diazonium species for producing a preferential reaction, since *Bahr* expressly teaches a reaction of semiconducting carbon nanotubes. Further, a preferential reaction of metallic and semimetallic carbon nanotubes over semiconducting nanotubes is not inherent from *Bahr* or established through routine experimentation. *Bahr's* purpose is to achieve highly functionalized carbon nanotubes. As would be evident to one skilled in the art, there is no motivation to use a deficiency (substoichiometric amount) of a diazonium species to produce the highly functionalized carbon nanotubes taught by *Bahr*.

Since *Bahr* does not teach all of the limitations of independent claim 1, as amended, either expressly or inherently, Applicants assert patentability of this claim over *Bahr*. An anticipation rejection under 35 U.S.C. § 102 requires each claim element to be present in the cited art either expressly or inherently. M.P.E.P. § 2131, *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). Likewise, since *Bahr* does not teach all of the limitations of independent claim 2, as amended, either expressly or inherently, Applicants assert patentability of this claim over *Bahr*. Claims 4, 5 and 7 – 12 depend either directly or indirectly from allowable claims 1 and 2 and are patentable for at least the same reasons. *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596 (Fed. Cir. 1988). Therefore,

Applicants respectfully request that the Examiner's rejection of claims 1, 2, 4, 5, 8, 10 and 12 under 35 U.S.C § 102(b) be withdrawn in view of the foregoing remarks and amendments.

VI.2 Claims 1, 2, 4, 5, 8, 10 and 12 rejected under 35 U.S.C. § 102(e)

Claims 1, 2, 4, 5, 7, 8, 10 and 12 stand rejected under 35 U.S.C. § 102(e) as unpatentable over WO 02/060812 (hereinafter, *Tour*). Office Action page 8, item 9. Applicants respectfully traverse the rejection of these claims.

The Examiner asserts that *Tour* teaches a process for modifying carbon nanotubes by reacting carbon nanotubes with a diazonium species. The Examiner asserts that the carbon nanotubes can be multi- and single-wall carbon nanotubes. The Examiner asserts that the aryl diazonium salts of claims 7 and 8 are taught by *Tour*. The Examiner asserts that *in situ* generation of a diazonium species from a substituted aniline species is taught by *Tour*. Further, the Examiner asserts that *Tour* teaches that carbon nanotubes can be defunctionalized via heat.

Applicants' reading of *Tour* follows. *Tour* teaches reactions of carbon nanotubes with diazonium species under electrochemical, thermal, and photochemical conditions. *Tour* teaches conditions under which semiconducting carbon nanotubes are at least partially functionalized (for example, see *Tour*, page 11, lines 9 – 20 and Figures 3 and 4). The fine structural features displayed in the unfunctionalized, purified SWNT-p absorption spectrum shown in Figure 3 of *Tour* are taught to be characteristic of semiconducting carbon nanotubes. The fine structural features disappear or are radically altered in the absorption spectra of SWNTs 1 – 12 as described on page 11, lines 13 – 18 and shown in Figures 3 and 4. This spectral alteration is taught by *Tour* to be consistent with covalent functionalization of semiconducting SWNTs (for example, see *Tour*, page 11, lines 18 – 20).

Applicants' claim 1 is distinguished from *Tour* in that *Tour* clearly does not teach a substoichiometric amount of a functionalizing species for producing a preferential reaction, since *Tour* expressly teaches a reaction of semiconducting carbon nanotubes. Further, a preferential reaction of metallic and semimetallic carbon nanotubes over semiconducting nanotubes is not inherent from *Tour* or established through routine experimentation. *Tour's* purpose is to achieve highly functionalized carbon nanotubes. As would be evident to one skilled in the art, there is no

motivation to use a deficiency (substoichiometric amount) of a diazonium species to produce the highly functionalized carbon nanotubes taught by *Tour*.

Likewise, Applicants' claim 2 is distinguished from *Tour* in that *Tour* clearly does not teach a substoichiometric amount of a diazonium species for producing a preferential reaction, since *Tour* expressly teaches a reaction of semiconducting carbon nanotubes. Further, a preferential reaction of metallic and semimetallic carbon nanotubes over semiconducting nanotubes is not inherent from *Tour* or established through routine experimentation. *Tour's* purpose is to achieve highly functionalized carbon nanotubes. As would be evident to one skilled in the art, there is no motivation to use a deficiency (substoichiometric amount) of a diazonium species to produce the highly functionalized carbon nanotubes taught by *Tour*.

Since *Tour* does not teach all of the limitations of independent claim 1, as amended, either expressly or inherently, Applicants assert patentability of this claim over *Tour*. Likewise, since *Tour* does not teach all of the limitations of independent claim 2, as amended, either expressly or inherently, Applicants assert patentability of this claim over *Tour*. Claims 4, 5 and 7 – 12 depend either directly or indirectly from allowable claims 1 and 2 and are patentable for at least the same reasons. Therefore, Applicants respectfully request that the Examiner's rejection of claims 1, 2, 4, 5, 7, 8, 10 and 12 under 35 U.S.C. § 102(e) be withdrawn in view of the foregoing remarks and amendments.

VII. Claim Rejections Under 35 U.S.C. § 103

VII.1 Claims 3 and 6 rejected under 35 U.S.C. § 103(a)

Claims 3 and 6 stand rejected under 35 U.S.C. § 103(a) as unpatentable over *Bahr* in view of *Krupke, et al., Science*, 2003, **301**, pp. 344 – 347 (hereinafter, *Krupke*). Office Action page 10, item 10. Applicants respectfully traverse the rejection of these claims.

The Examiner asserts that *Bahr* does not expressly teach an aqueous surfactant solution. However, the Examiner asserts that *Krupke* teaches that a stable solution of individual SWNTs can be obtained by homogenizing a suspension of SWNTs in water in the presence of a surfactant. The Examiner asserts that it would have been obvious at the time of invention for one skilled in the art to incorporate a surfactant into the practice of selectively functionalizing

carbon nanotubes.

Applicants' comments regarding *Bahr* presented hereinabove are hereby incorporated by reference. Applicants assert that *Krupke* teaches separation of metallic carbon nanotubes from semiconducting carbon nanotubes. *Krupke* teaches that the carbon nanotubes are dispersed in a 1% SDS solution and then separated by electrophoresis.

Applicants assert that the cited references do not teach or suggest all of the limitations of claim 3, as amended, either individually or in combination. Applicants have amended claim 3 to recite a limitation that a substoichiometric amount of a diazonium species is selected such that a preferential reaction of the diazonium species occurs with metallic and semimetallic carbon nanotubes over semiconducting carbon nanotubes. Applicants' claim 3 is distinguished from *Bahr* in that *Bahr* clearly does not teach or suggest a substoichiometric amount of a diazonium species for producing a preferential reaction, since *Bahr* expressly teaches a reaction of semiconducting carbon nanotubes. Likewise, *Krupke* does not teach or suggest the limitations of claim 3. Electrophoresis is a physical separation technique, and no chemical reaction is taught or suggested by *Krupke*. Therefore, *Krupke* does not teach or suggest the limitation of a substoichiometric amount of a diazonium species for producing a preferential reaction.

In view of the foregoing remarks, Applicants assert that the cited references do not teach or suggest all of the limitations of Applicants' independent claim 3, as amended, either singularly or in combination. For rejections under 35 U.S.C. § 103(a), all claim limitations must be taught or suggested by the prior art to establish obviousness. *In re Royka*, 490 F.2d 981, 180 U.S.P.Q. 580 (C.C.P.A. 1974). Therefore, Applicants assert that independent claim 3 is allowable. Claims 4 – 12 and 25 depend either directly or indirectly from independent claim 3 and are patentable for at least the same reasons. *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596 (Fed. Cir. 1988). Therefore, withdrawal of the Examiner's rejection of claims 3 and 6 under 35 U.S.C § 103(a) in view of the foregoing remarks and amendments is respectfully requested.

VII.2 Claim 9 rejected under 35 U.S.C. § 103(a)

Claim 9 stands rejected under 35 U.S.C. § 103(a) as unpatentable over *Bahr* in view of United States Patent 5,851,280 (hereinafter, *Belmont*). Office Action page 10, item 11.

Applicants respectfully traverse the rejection of this claim.

The Examiner asserts that *Bahr* anticipates a variety of diazonium compounds prepared from the corresponding aniline derivatives. The Examiner presents evidence that substitutions of different functional groups can be present for the diazotization reaction (Sci-Tech Dictionary, McGraw-Hill Dictionary of Scientific and Technical Terms, 2003). Although *Bahr* does not teach or suggest using an alkyl nitrite to generate the diazonium compound, the Examiner asserts that *Belmont* teaches formation of diazonium salts in a variety of ways, including *in situ* formation. Therefore, the Examiner asserts that it would have been obvious for one of ordinary skill in the art to use an alkyl nitrite to produce the diazonium compound

Applicants' comments regarding *Bahr* presented hereinabove are hereby incorporated by reference. Applicants assert that *Belmont* teaches reactions of diazonium salts with carbon black in the absence of an applied electrical current. *Belmont* does not teach or suggest a reaction of carbon nanotubes.

Claim 9 depends directly from independent claims 2 and 3. Applicants assert that the cited references do not teach or suggest all of the limitations of either claims 2 or 3, as amended, either individually or in combination. As discussed hereinabove, Applicants' claim 2 is distinguished from *Bahr* in that *Bahr* does not teach or suggest a substoichiometric amount of a diazonium species for producing a preferential reaction, since *Bahr* expressly teaches a reaction of semiconducting carbon nanotubes. Also as discussed hereinabove, Applicants' claim 3 is distinguished from *Bahr* in that *Bahr* clearly does not teach or suggest a substoichiometric amount of a diazonium species for producing a preferential reaction, since *Bahr* expressly teaches a reaction of semiconducting carbon nanotubes. With reference to both claims 2 and 3, *Belmont* does not teach or suggest a substoichiometric amount of a diazonium species for producing a preferential reaction of metallic and semimetallic carbon nanotubes over semiconducting carbon nanotubes. *Belmont* does not teach or suggest a reaction of carbon nanotubes at all.

In view of the foregoing remarks, Applicants assert that the cited references do not teach or suggest all of the limitations of Applicants' independent claims 2 or 3, as amended, either singularly or in combination. Therefore, Applicants assert that independent claims 2 and 3 are

allowable. Claim 9 depends directly from allowable claims 2 and 3 and is patentable for at least the same reasons. Therefore, withdrawal of the Examiner's rejection of claim 9 under 35 U.S.C. § 103(a) in view of the foregoing remarks and amendments is respectfully requested.

VII.3 Claim 11 rejected under 35 U.S.C. § 103(a)

Claim 11 stands rejected under 35 U.S.C. § 103(a) as unpatentable over *Bahr* in view of *Tsuchida, et al., Die Makromolekulare Chemie*, 1970, **132**, pp. 209 – 213 (hereinafter, *Tsuchida*) and United States Patent 4,264,529 (hereinafter, *Dunn*). Office Action page 11, item 12. Applicants respectfully traverse the rejection of this claim.

The Examiner's assertions concerning *Bahr* are fully incorporated by reference, wherein *Bahr* anticipates a variety of functional groups that can be used as the R group in the diazonium compound. Although *Bahr* does not expressly teach or suggest that the functional group is a hydroxyl group, the Examiner asserts that *Tsuchida* teaches that p-aminophenol has reversible oxidation and reduction properties because of the presence of both the hydroxyl and amine groups. Further, the Examiner asserts that *Dunn* teaches that p-aminophenol derivatives have a wide variety of industrial applications. The Examiner therefore asserts that it would have been obvious for one of ordinary skill in the art to adopt a hydroxyl group on the aniline species during diazonium salt formation for use in later functional modification.

Applicants' comments regarding *Bahr* presented hereinabove are hereby incorporated by reference. Applicants assert that neither *Tsuchida* nor *Dunn* teach or suggest a reaction of carbon nanotubes.

Claim 11 depends indirectly from independent claims 2 and 3. Applicants assert that the cited references do not teach or suggest all of the limitations of either claims 2 or 3, as amended, either individually or in combination. As discussed hereinabove, Applicants' claim 2 is distinguished from *Bahr* in that *Bahr* does not teach or suggest a substoichiometric amount of a diazonium species for producing a preferential reaction, since *Bahr* expressly teaches a reaction of semiconducting carbon nanotubes. Also as discussed hereinabove, Applicants' claim 3 is distinguished from *Bahr* in that *Bahr* clearly does not teach or suggest a substoichiometric amount of a diazonium species for producing a preferential reaction, since *Bahr* expressly

teaches a reaction of semiconducting carbon nanotubes. With reference to both claims 2 and 3, neither *Tsuchida* nor *Dunn* teach or suggest a substoichiometric amount of a diazonium species for producing a preferential reaction of metallic and semimetallic carbon nanotubes over semiconducting carbon nanotubes.

In view of the foregoing remarks, Applicants assert that the cited references do not teach or suggest all of the limitations of Applicants' independent claims 2 or 3, as amended, either singularly or in combination. Therefore, Applicants assert that independent claims 2 and 3 are allowable. Claim 11 depends indirectly from allowable claims 2 and 3 and is patentable for at least the same reasons. Therefore, withdrawal of the Examiner's rejection of claim 11 under 35 U.S.C § 103(a) in view of the foregoing remarks and amendments is respectfully requested.

CONCLUSIONS

Applicants respectfully submit that Claims 1 – 12 and 25, as they presently stand amended, are in a condition for allowance based on the remarks and amendments presented hereinabove.

If additional fees are due and are not included, the Director is hereby authorized to charge any fees or credit any overpayment to Deposit Account Number 23-2426 of Winstead PC (referencing matter 11321-P071WOUS).

If the Examiner has any questions or comments concerning this paper or the present application in general, the Examiner is invited to call the undersigned at 713-650-2782.

Respectfully submitted,

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